

Nickel alloy steels with specified low temperature properties Compared

1 According to EN 10028-4:2003 and JIS G 3127-2005 standard grades.

2 Standards grade Table 1.

Table 1

Standards No.	Grade
GBT	0.5NiA, 0.5NiB, 1.5Ni, 2Ni, 3Ni255, 3Ni275, 3Ni440, 3.5Ni, 5Ni, 9Ni, 9Ni590, 9Ni520
CCS	0.5NiA, 0.5NiB, 1.5Ni, 3.5Ni, 5Ni, 9Ni
DNV	1.5Ni, 3.5Ni, 5Ni, 9Ni
LR	1.5Ni, 3.5Ni, 5Ni, 9Ni
EN 10028-4: 2003	11MnNi5-3, 13MnNi6-3, 15NiMn6, 12Ni14, X12Ni5, X8Ni9, X7Ni9
JIS G 3127-2005	SL2N255, SL3N255, SL3N275, SL3N440, SL5N590, SL9N520, SL9N590

3 Chemical composition (cast analysis)

Table 2

Standard	Grade	Chemical composition % by mass											
		C	Si	Mn	Ni	Cr ≤	Cu ≤	Nb ≤	V ≤	Mo ≤	Als ≥	P Maximum	S
GBT	0.5NiA	≤0.14	0.10~0.50	0.70~1.60	0.30~0.80	0.25	0.35	0.05	0.05	0.08	0.015	0.015	0.010
CCS	0.5NiA	≤0.14	0.10~0.50	0.70~1.60	0.30~0.80	0.25	0.35	--	--	0.08	0.015	0.025	0.020
EN 10028-4	11MnNi5-3	≤0.14	≤0.50	0.70~1.50	0.30~0.80	--	--	0.05	0.05	--	0.015	0.025	0.015
	13MnNi6-3	≤0.16	≤0.50	0.85~1.70	0.30~0.85	--	--	0.05	0.05	--	0.015	0.025	0.015
GBT	0.5NiB	≤0.16	0.10~0.50	0.70~1.60	0.50~0.80	0.25	0.35	0.05	0.05	0.08	0.015	0.015	0.010
CCS	0.5NiB	≤0.16	0.10~0.50	0.70~1.60	0.50~0.80	0.25	0.35	--	--	0.08	0.015	0.025	0.020
GBT	1.5Ni	≤0.14	0.10~0.35	0.30~1.50	1.30~1.70	0.25	0.35	0.05	0.05	0.08	0.015	0.015	0.010
CCS	1.5Ni	≤0.14	0.10~0.35	0.30~1.50	1.30~1.70	0.25	0.35	--	--	0.08	0.015	0.025	0.020
DNV	1.5Ni	≤0.14	0.10~0.35	0.30~1.50	1.30~1.70	--	--	--	--	--	0.013	0.025	0.025
LR	1.5Ni	≤0.18	0.10~0.35	0.30~1.50	1.30~1.70	0.25	0.35	--	--	0.08	0.015	0.025	0.020
EN 10028-4	15NiMn6	≤0.18	≤0.35	0.80~1.50	1.30~1.70	--	--	--	0.05	--	--	0.025	0.015
GBT	2Ni	≤0.17	≤0.30	≤0.70	2.10~2.50	0.25	0.35	0.08	0.05	0.08	0.015	0.015	0.010
	3Ni255	≤0.15	≤0.30	≤0.70	3.25~3.75	0.25	0.35	0.08	0.05	0.08	0.015	0.015	0.010
	3Ni275	≤0.17	≤0.30	≤0.70	3.25~3.75	0.25	0.35	0.08	0.05	0.08	0.015	0.015	0.010
	3Ni440	≤0.15	≤0.30	≤0.70	3.25~3.75	0.25	0.35	0.08	0.05	0.08	0.015	0.015	0.010
JIS G 3127	2Ni255	≤0.17	≤0.30	≤0.70	2.10~2.50	--	--	--	--	--	--	0.025	0.025
	3Ni255	≤0.15	≤0.30	≤0.70	3.25~3.75	--	--	--	--	--	--	0.025	0.025
	3Ni275	≤0.17	≤0.30	≤0.70	3.25~3.75	--	--	--	--	--	--	0.025	0.025
GBT	3Ni440	≤0.15	≤0.30	≤0.70	3.25~3.75	--	--	--	--	--	--	0.025	0.025
	3.5Ni	≤0.12	0.10~0.35	0.30~0.80	3.25~3.75	0.25	0.35	0.08	0.05	0.08	0.015	0.015	0.010

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CCS	3.5Ni	≤0.12	0.10~0.35	0.30~0.80	3.20~3.80	0.25	0.35	--	--	0.08	0.015	0.025	0.020
DNV	3.5Ni	≤0.12	0.10~0.35	0.30~0.70	3.25~3.75	--	--	--	--	--	0.013	0.025	0.025
LR	3.5Ni	≤0.15	0.10~0.35	0.30~0.90	3.20~3.80	0.25	0.35	--	--	0.08	0.015	0.025	0.020
EN 10028-4	12Ni14	≤0.15	≤0.35	0.30~0.80	3.25~3.75	--	--	--	0.05	--	--	0.020	0.010
GBT	5Ni	≤0.12	0.10~0.35	0.30~0.90	4.70~5.30	0.25	0.35	0.08	0.05	0.08	0.015	0.015	0.010
	5Ni590	≤0.13	≤0.30	≤1.50	4.75~6.00	0.25	0.35	0.08	0.05	0.08	0.015	0.015	0.010
CCS	5Ni	≤0.12	0.10~0.35	0.30~0.90	4.70~5.30	0.25	0.35			0.08	0.015	0.025	0.020
DNV	5Ni	≤0.12	0.10~0.35	0.30~0.80	4.70~5.30	--	--	--	--	--	0.013	0.025	0.025
LR	5Ni	≤0.12	0.10~0.35	0.30~0.90	4.70~5.30	0.25	0.35	--	--	0.08	0.015	0.025	0.020
EN 10028-4	X12Ni5	≤0.15	≤0.35	0.30~0.80	4.75~5.25	--	--	--	0.05	--	--	0.020	0.010
JIS G 3127	5Ni590	≤0.13	≤0.30	≤1.50	4.75~6.00	--	--	--	--	--	--	0.025	0.025
GBT	9Ni	≤0.10	0.10~0.35	0.30~0.90	8.50~10.0	0.25	0.35	0.08	0.05	0.08	0.015	0.010	0.010
	9Ni520 9Ni590	≤0.12	≤0.30	≤0.90	8.50~9.50	0.25	0.35	0.08	0.05	0.08	0.015	0.010	0.010
CCS	9Ni	≤0.10	0.10~0.35	0.30~0.90	8.50~10.0	0.25	0.35	--	--	0.08	0.015	0.025	0.020
DNV	9Ni	≤0.10	0.10~0.35	0.30~0.90	8.50~10.0	--	--	--	--	--	0.013	0.025	0.025
LR	9Ni	≤0.10	0.10~0.35	0.30~0.90	8.50~10.0	0.25	0.35	--	--	0.08	0.015	0.025	0.020
EN 10028-4	X8Ni9	≤0.10	≤0.35	0.30~0.80	8.50~10.0	--	--	--	0.05	--	0.1	0.020	0.010
	X7Ni9	≤0.10	≤0.35	0.30~0.80	8.50~10.0	--	--	--	0.01	--	0.1	0.015	0.005
JIS G 3127	9Ni520 9Ni590	≤0.12	≤0.30	≤0.90	8.50~9.50	--	--	--	--	--	--	0.025	0.025
Notice:1: CCS、LR: Cr+Mo+Cu≤0.60%。													
Notice: 2: EN 10028-4: Cr+Mo+Cu≤0.50%。													

4 Steelmaking process:

EAF+LF+VOD

5 Delivery condition:

Table 3

Grade	Delivery condition ^a
0.5NiA、0.5NiB、1.5Ni、2Ni255、3Ni255、 3Ni275、3Ni400、3.5Ni、5Ni、9Ni590	N、N+T、TMCP or Q+T
9Ni	Twice N+T or Q+T
9Ni520	Twice N+T
^a Recommend Tempering at temperature: 540℃~600℃。	
For product thickness ≤15 mm, delivery conditions +N plus +NT are also applicable.	

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6 Mechanical properties

6.1 Yield strength

Table 4

GBT		classification society rules		EN10028-4	
Grade	Yield strength MPa min.	Grade	Yield strength MPa min.	Grade	Yield strength MPa min.
0.5NiA	285	CCS--0.5NiA	285	11MnNi5-3	285
1.5Ni	275	CCS、DNV--1.5Ni	275	15NiMn6	355
3.5Ni	345	CCS--3.5Ni	345	12Ni14	355
		DNV--3.5Ni	345		
		LR--3.5Ni	285		
5Ni	390	CCS--5Ni	390	X12Ni5	390
		DNV--5Ni			
		LR--5Ni			
9Ni	490	CCS--9Ni	490	X8Ni9	490
		DNV--5Ni			
		LR--5Ni			
JIS G					
9Ni520	520	9Ni520	520	X8Ni9	585
9Ni590	590	9Ni590	590	X7Ni9	

6.2 Tensile strength

Table 5

GBT		classification society rules		EN10028-4	
Grade	Tensile strength MPa	Grade	Tensile strength MPa	Grade	Tensile strength MPa
0.5NiA	420--530	CCS--0.5NiA	400--530	11MnNi5-3	420--530
1.5Ni	490--640	CCS、DNV--1.5Ni	470--640	15NiMn6	490--640
3.5Ni	490--690	CCS--3.5Ni	440--690	12Ni14	490--640
		DNV--3.5Ni	540--690		
		LR--3.5Ni	450--610		
5Ni	540--710	CCS--5Ni	520--710	X12Ni5	530--710
		DNV--5Ni	570--710		
		LR--5Ni	540--740		
9Ni	640--830	CCS--9Ni	640--830	X8Ni9	640--840
		DNV--5Ni	640--840		
		LR--5Ni	640--790		
JISG					
9Ni520	690--830	9Ni520	690--830	X8Ni9	680--820
9Ni590		9Ni590		X7Ni9	

7 Minimum impact energy values (valid for V-notched test pieces)

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Steel grade		Heat treatment condition ^{a,b}	Product thickness mm	Direction	Minimum impact energy KV in J												
Steel name	Steel number				at a temperature in °C of												
11MnNi5-3	1.6212	+N (+NT)	5 °C to 80	longitudinal	20	0	-20	-40	-50	-60	-80	-100	-120	-150	-170	-196	
13MnNi6-3	1.6217			transverse	70	60	55	50	45	40	-	-	-	-	-	-	-
15NiMn6	1.6228	+N or +NT or +QT		longitudinal	65	65	65	60	50	50	40	-	-	-	-	-	-
				transverse	50	50	45	40	35	35	27	-	-	-	-	-	-
12Ni14	1.5637	+N or +NT or +QT	longitudinal	65	60	55	55	50	50	45	40	-	-	-	-	-	-
			transverse	50	50	45	35	35	35	30	27	-	-	-	-	-	-
X12Ni5	1.5680	+N or +NT or +QT	longitudinal	70	70	70	65	65	65	60	50	40 ^d	-	-	-	-	-
			transverse	60	60	55	45	45	45	40	30	27 ^d	-	-	-	-	-
X8Ni9+NT640; X8Ni9+QT640 ^a	1.5662+NT640; 1.5662+QT640 ^a	+N plus +NT; +QT	longitudinal	100	100	100	100	100	100	100	90	80	70	60	50	40	30
			transverse	70	70	70	70	70	70	70	60	50	50	45	45	40	30
X8Ni9 +QT680 ^a	1.5662 +QT680 ^a	+QT	longitudinal	120	120	120	120	120	120	120	110	100	90	80	70	60	50
			transverse	100	100	100	100	100	100	100	90	80	70	60	50	40	30
X7Ni9	1.5663	+QT	longitudinal	120	120	120	120	120	120	120	120	120	120	120	110	100	90
			transverse	100	100	100	100	100	100	100	100	100	100	100	100	90	80

^a +N: normalized; +NT: normalized and tempered; +QT: quenched and tempered; +NT640+QT640/+QT680: Heat treatment variant with minimum tensile strength of 640 MPa or 680 MPa.
^b For temperatures and cooling conditions, see Table A.1.
^c See 10.2.2.3 in EN 10028-1:2000 + A1:2002.
^d The values are applicable for product thicknesses ≤ 25 mm at -110 °C and for product thicknesses of 25 mm < t ≤ 30 mm at -115 °C.

8. Annex A

Compared grades

Standard	GBT	EN 10028 -4:2003	JIS G 3127-2005	CCS 2007	DNV 2007	LR 2007	ASME A553 -2006
Grade	0.5NiA	11MnNi5-3		0.5NiA			
	0.5NiB	13MnNi6-3		0.5NiB			
	1.5Ni	15NiMn6		1.5Ni	1.5Ni	1.5Ni	
	2Ni		SL2N255				
	3Ni255 3Ni275 3Ni400		SL3N255 SL3N275 SL3N440				
	3.5Ni	12Ni14		3.5Ni	3.5Ni	3.5Ni	
	5Ni	X12Ni5	SL5N590	5Ni	5Ni	5Ni	
	9Ni	X8Ni9		9Ni	9Ni	9Ni	
	9Ni520 9Ni590	X8Ni9 X7Ni9	SL9N520 SL9N590				Type I Type II

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